Do You Really Mean It? Linking Lexical Semantic Profiles and the Age of Acquisition for the English Passive

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1. Introduction

Within the domain of passives, children have been shown to be delayed in their understanding of *by*-phrase passives like (1-2) (Bever, 1970; de Villiers & de Villiers, 1973; Horgan, 1978). Several studies have also noted that children's performance depends on the lexical semantics of the verb (Maratsos et al., 1985; Messenger et al., 2012; Nguyen, 2015; Liter et al., 2015). For example, younger children perform better on passives with ACTIONAL verbs like *hug* (1) compared to non-ACTIONAL verbs like *love* (2).

(1) Alex was hugged by Emma.

(2) Alex was loved by Emma.

Several factors have been proposed to explain the general delay in understanding passives (e.g., frequency: Demuth et al. 2010; lexical semantic: Maratsos et al. 1985; syntactic: Borer & Wexler 1987; pragmatic: O'Brien et al. 2006). Here, we examine the influence of frequency and lexical semantic factors on English children's acquisition of *by*-phrase passives. We conduct both a meta-analysis of experimental studies capturing the age of acquisition for the passive use of English verbs and a corpus analysis of English children's input. We find no relationship at all between the demonstrated age of acquisition (**AoA**) and input frequency, whether we examine frequency of the individual verb in the passive or frequency of the individual verb in any form. However, there is a striking correlation between the lexical semantic profile of verbs and the AoA for their passive use by English-speaking children.

We first describe the frequency and lexical semantic factors potentially impacting passive acquisition in more detail. We then discuss the meta-analysis of experimental results, the corpus analysis of children's input, and the lexical semantic analysis. Our findings suggest lexical semantics are a key variable impacting children's performance on the English passive. We conclude with promising future experimental, corpus, computational, and theoretical directions.

2. Frequency and lexical semantic features

2.1. Frequency

One way to explain English children's differing performance by specific verb on *by*-phrase passives is a very direct one: Children hear some verbs in the passive form more than others, and so perform better on the verbs they hear more frequently in the passive. Crain & Fodor (1989) note that English-speaking children and adults rarely produce *by*-phrase passives.[1] So, children's *by*-phrase passive performance by verb could simply be a direct reflection of their *by*-phrase input by verb. If this is the core factor driving children's performance, we expect children's input to be strongly correlated with their performance. In particular, we would expect that a verb's **passive frequency** in the input is strongly correlated with

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[1] This is corroborated by our own corpus analysis in section 3.2, where passives of any kind comprise only 0.5% of all verb uses.

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children's performance on that verb: the more passive input there is for a verb, the better performance should be on that verb. Developmentally, this may appear as an earlier AoA for verbs with higher passive frequency in the input.

An alternative frequency-based hypothesis would be one based not on individual verb passive frequency, but rather simply individual **verb frequency**. The idea here would be that the passive is a more difficult structure for children to process and so verbs that are themselves easier to access are the ones children perform better on for the passive. That is, the difficulty is not with the passive structure per se, but rather with deploying knowledge of the passive in real time for an individual verb (Omaki & Lidz, 2015). So, when a verb itself is more accessible, that verb is easier for children to understand in the passive form. The main way a verb would be more accessible is through exposure to that verb in the input, in any of its forms (active or passive). Under this view, the more frequent a verb is in children's input in any of its forms, the better children's performance on the passive should be; developmentally, an earlier AoA would occur for verbs with higher frequency in the input.

2.2. Lexical semantic features

Another way of explaining children's differing performance on *by*-phrase passives relies on the lexical semantic features of the individual verbs. Several experimental studies (Maratsos et al., 1985; Pinker et al., 1987; Messenger et al., 2012; Nguyen, 2015; Liter et al., 2015) have collectively described seven potentially relevant lexical semantic features impacting children's performance (Table 1): ACTIONAL, STATIVE, VOLITIONAL, AFFECTED, and the thematic-role relations object-experiencer (OBJ-EXP), subject-experiencer (SUBJ-EXP), and agent-patient (AGT-PAT). However, there has not yet been a formal account of how well these descriptive features capture differential development of the *by*-phrase passive. These are the seven lexical semantic features we will use in our corpus analysis.

Table 1: Descriptive lexical semantic features derived from prior experimental studies, including signals of that feature and example verbs with (+) and without (-) that feature.

Studies	**Feature**	**Signal**	**+**	**-**
Maratsos et al. (1985) Nguyen (2015)	ACTIONAL	Observable	*eat*	*scare*
Liter et al. (2015)	STATIVE	Simple present tense in "out of the blue" context	*scare*	*eat*
Liter et al. (2015)	VOLITIONAL	"deliberately *VERB*"	*annoy*	*see*
Pinker et al. (1987)	AFFECTED	X affects Y	*annoy*	*like*
Messenger et al. (2012)	OBJ-EXP	-ACTIONAL where object is Experiencer	*frighten*	*chase*
Messenger et al. (2012)	SUBJ-EXP	-ACTIONAL where subject is Experiencer	*like*	*annoy*
Messenger et al. (2012)	AGT-PAT	+ACTIONAL where θ-roles = Agent, Patient	*eat*	*whisper*

The first feature is ACTIONAL, which was defined by Maratsos et al. (1985) as a verb that is *not* a mental, psych, or perception verb. A signal we use to identify an ACTIONAL verb is whether the event described by the verb is observable. So, *eat* would be +ACTIONAL because eating can be directly observed (e.g., *The penguin is eating a fish* – we can observe the penguin eating the fish). In contrast, a psych verb like *scare* would be -ACTIONAL because the internal state caused by scaring cannot be directly observed (e.g., *Spiders scare Lisa* – we cannot observe Lisa's internal state of mortal terror at arachnids because that psychological state is internal to Lisa).

The next features, STATIVE and VOLITIONAL, were proposed by Liter et al. (2015). Stativity is defined as a verb being acceptable in the simple present tense in an "out of the blue" context. For example, *Spiders scare me* sounds acceptable without any special context (*scare*=+STATIVE). This contrasts with *The penguin eats a fish*, which sounds odd out of the blue unless we are narrating an event in real time (*eat*=-STATIVE). Liter et al. (2015) define a verb as VOLITIONAL if it is acceptable when following the adverb *deliberately*. For example, *Jack deliberately annoyed Lily* sounds acceptable, and describes an event where Jack made a concerted effort to annoy Lily (*annoy*=+VOLITIONAL). In

contrast, *Jack deliberately saw Lily* sounds somewhat odd in its default interpretation, as it describes an event where Jack has preternatural control over his visual perception and can choose whether to consciously perceive Lily (*see*=-VOLITIONAL).

The AFFECTED feature was proposed by Pinker et al. (1987), and applies to verbs where the subject affects the object. For example, in *Jack annoyed Lily*, Lily is affected by Jack – she is, in fact, annoyed by him (*annoy*=+AFFECTED). This contrasts with *Jack liked Lily*, where Lily isn't impacted by Jack liking her, even though Jack is (*like*=-AFFECTED).

The final three features, OBJ-EXP, SUBJ-EXP, and AGT-PAT, were proposed by Messenger et al. (2012), and focus on the thematic status of the object (as either an Experiencer or a Patient). When verbs are -ACTIONAL, they often involve Experiencers. A verb is +OBJ-EXP when the Experiencer is the object (e.g., *Jack frightens Lily* – Lily is the Experiencer of the fright). A verb is +SUBJ-EXP when the Experiencer is the subject (e.g., *Jack likes Lily* – Jack is the Experiencer of the liking). When verbs are +ACTIONAL and the thematic roles are Agent and Patient, the verb is AGT-PAT. For example, *The penguin eats the fish* describes an event where the penguin is the agent and the fish is the patient (*eat*=+AGT-PAT). This contrasts with *whisper* (e.g., *Jack whispered the secret*), which is +ACTIONAL but does not obviously involve Agent and Patient roles; therefore, it is -AGT-PAT.

We demonstrate the lexical semantic annotation of verbs according to these signals in Table 2. *Find* is an observable action (ACTIONAL=1, STATIVE=0) that is not deliberate (VOLITIONAL=0). In a transitive use, the direct object is unaffected (AFFECTED=0) and a Patient (OBJ-EXP=0, SUBJ-EXP=0, AGT-PAT=1). CARRY is also an observable action (ACTIONAL=1, STATIVE=0), but can be deliberate (VOLITIONAL=1). In a transitive use, the direct object is affected (AFFECTED=1) and a Patient (OBJ-EXP=0, SUBJ-EXP=0, AGT-PAT=1). *Love* is a stative psych verb (ACTIONAL=0, STATIVE=1) that is not deliberate (VOLITIONAL=0). In a transitive use, the direct object is unaffected (AFFECTED=0) and the subject is the Experiencer (OBJ-EXP=0, SUBJ-EXP=1, AGT-PAT=0).

Table 2: Example reasoning for identification of lexical semantic features in the verbs *find, carry*, and *love*.

	find	***carry***	***love***
ACTIONAL	*find* ≠ mental, psych, or perception verb. **1**	*carry* ≠ mental, psych, or perception verb. **1**	*love* = psych verb. **0**
STATIVE	*Alex finds Emma. **0**	*Alex carries Emma. **0**	Alex loves Emma. **1**
VOLITIONAL	*Alex deliberately finds Emma. **0**	Alex deliberately carries Emma. **1**	*Alex deliberately loves Emma. **0**
AFFECTED	Alex finds Emma – Emma is unaffected. **0**	Alex carries Emma – Emma is affected. **1**	Alex loves Emma – Emma is unaffected. **0**
OBJ-EXP SUBJ-EXP AGT-PAT	Alex finds Emma. Alex = Agent. Emma = Patient. **0** **0** **1**	Alex carries Emma Alex = Agent. Emma = Patient. **0** **0** **1**	Alex loves Emma Alex = Experiencer. Alex = Subject. **0** **1** **0**

3. Analyses & findings

3.1. Experimental meta-analysis

We synthesized the results of 12 experimental studies, summarizing (i) the verbs used as stimuli (Table 3), and (ii) children's performance on *by*-phrase passives for those verbs at different ages (Table 4). This provided the empirical data about the "age of acquisition" (**AoA**) for each verb. We determined a verb's AoA by assessing the age when children begin performing significantly above chance in any of the studies. Of the 50 unique verbs tested in these 12 studies, 30 had an AoA by this definition, as shown

in Table 4.[2] We subsequently analyzed the passive frequency and verb frequency of these 30 verbs in the input via a corpus analysis, and annotated them for their lexical semantic features according to the signals defined in Table 1.

Table 3: Studies and verbs used in experimental meta-analysis.

Studies	**Verbs tested**
de Villiers & de Villiers (1973)	kiss, push, hit, bite, bump, touch
Maratsos & Abramovitch (1975)	kick, kiss, push, hit, bite, bump, tickle, touch
Maratsos et al. (1985)	hold, kick, kiss, push, shake, wash, find, forget, hate, like, love, remember, hear, know, miss, see, smell, watch
Gordon & Chafetz (1990)	carry, drop, eat, hold, hug, kick, kiss, shake, wash, forget, hate, like, remember, believe, hear, know, see, watch
Fox & Grodzinsky (1998)	chase, hear, see, touch
Hirsch & Wexler (2006)	push, kiss, kick, hold, remember, love, hate, see
O'Brien et al. (2006)	hug, chase, like, see
Crain et al. (2009)	eat, kiss, push, hit, bite, crash, kill, knock, lick, pick up, punch, scratch, shoot
Messenger et al. (2012)	carry, hit, frighten, pat, pull, scare, shock, squash, surprise, upset, hate, love, remember, annoy, bite, hear, ignore, see
Orfitelli (2012)	carry, kick, kiss, push, love, remember, hear, see
Nguyen (2015)	hug, chase, like, see
Liter et al. (2015)	wash, find, fix, forget, paint, spot, hate, love, know

Table 4: AoA of verbs from experimental meta-analysis, representing an AoA by 3 years old (3yr), between 3 and 4 years old (3-4yr), between 4 and 5 years old (4-5yr), and 5 years old (5yr).

AoA	**Verbs**
3yr	carry, drop, eat, hold, hug, kick, kiss, push, shake, wash
3-4yr	annoy, chase, frighten, hit, pat, pull, scare, shock, squash, surprise, upset
4-5yr	find, fix, forget, paint, spot
5yr	hate, like, love, remember

3.2. Testing frequency

We examined child-directed speech utterances in the CHILDES Treebank (MacWhinney, 2000; Pearl & Sprouse, 2013) across two corpora: the Brown corpus (Brown, 1973) (including the Adam, Eve, and Sarah subcorpora) and the Valian corpus (Valian, 1991). This corpus analysis yielded 113,024 child-directed speech utterances (62,772 verb tokens, 747 verbs) directed at children ages 1;06-5;01, with 73% of these verbs being passivizable.[3] Despite the abundant opportunities for using a passive construction, only 361 tokens of 119 verbs were used in the passive, which accounts for only 0.5% of the total verb tokens. This highlights that the vast majority

Table 5: Seven of the most frequent verbs in children's input (Verb freq) that had an observed AoA, and the frequency of their passive use (Passive freq) in children's input.

Verb	**AoA**	**Verb freq**	**Passive freq**
like	5yrs	1150	0
eat	3yrs	654	2
find	4-5yrs	327	0
remember	5yrs	290	0
hold	3yrs	234	0
fix	4-5yrs	215	6
hit	3yrs	198	0

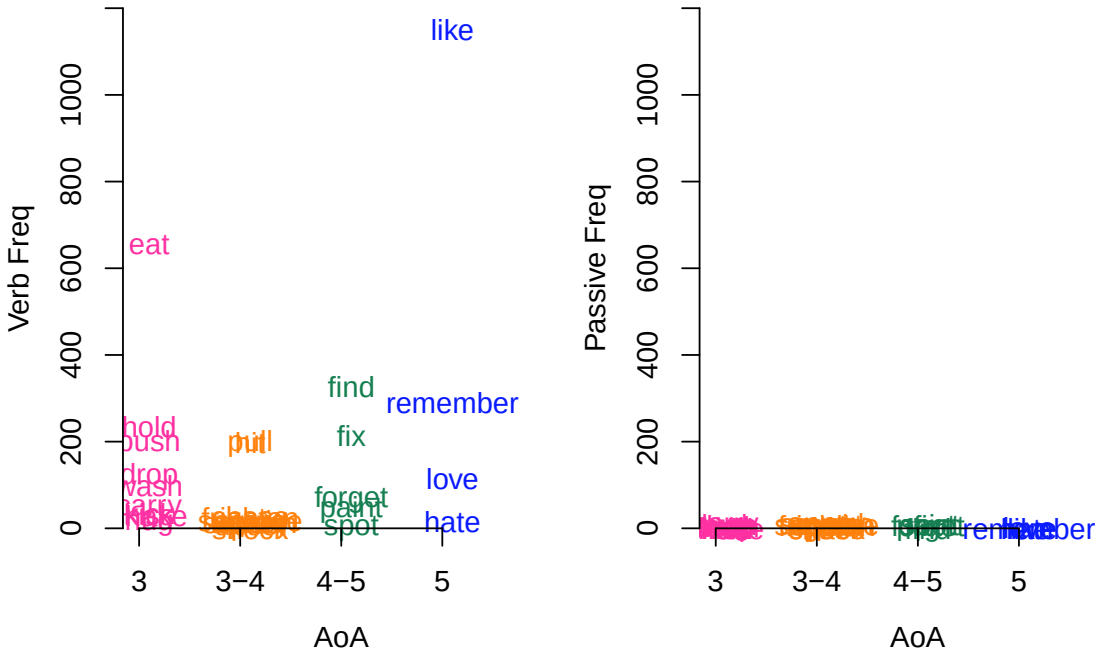
[2] The overlap in the ages was a consequent of our meta-analysis where studies often tested and collapsed across multiple age groups.

[3] For this analysis, we considered a verb passivizable if it (i) has a transitive form and, (ii) can take the passive form, such as *break* (*I broke it/It was broken*). This notably excludes intransitive verbs that can appear in the pseudopassive like *laugh* (*It was laughed at*).

of verb uses in children's input are not in the passive, aligning with Crain & Fodor (1989)'s assertion. For the 30 verbs from the experimental meta-analysis with an AoA, there were 4143 tokens of 27 verbs in this sample of child-directed speech. Notably, the passive form of these verbs was rarely produced for 12 of these 30 verbs (only 25 passive instances of these 12 verbs total).

Table 5 shows the seven most frequent verbs of these 30, including both their individual verb frequency and the frequency of their passive use.[4] Figure 1 compares both individual verb frequency and passive frequency against observed AoA for the 30 verbs from the meta-analysis. If either individual verb frequency or passive frequency in the input drive children's AoA for the *by*-phrase passive, there should be a negative correlation between these frequency factors and AoA.

Figure 1: Age of acquisition by verb frequency. Left: AoA and individual verb frequency. Right: AoA and passive use frequency.



As can be readily seen from Table 5 and Figure 1, there is very little correlation between individual verb frequency ($r = 0.29$)[5] or individual verb passive frequency ($r = 0.02$) and observed AoA. Moreover, within each AoA group of verbs, there is variation in input frequency for both individual verb use and passive use. This underscores that input frequency of an individual verb's use and passive use aren't the driving factors for children's differing performance by AoA.

3.3. Testing lexical semantic features

When verbs were sorted based on AoA (i.e. the age of significantly above-chance performance from the meta-analysis), we found that lexical semantic feature profiles emerged. Table 6 shows the lexical semantic feature profiles of verbs aligned by AoA. We see a striking relationship between the lexical semantic profile of a verb and that verb's observed AoA.

In particular, we observed 5 lexical semantic profiles for the 30 verbs. Profile 1 verbs include *carry*, *chase*, and *fix*, and are +ACTIONAL, +VOLITIONAL, +AFFECTED, and +AGT-PAT. Profile 2 verbs include *annoy*, and differ from Profile 1 verbs by being +STATIVE (instead of +ACTIONAL) and +OBJ-EXP (instead of +AGT-PAT). Profile 3 verbs include *find*, and are like Profile 1 verbs in being +ACTIONAL and +AGT-PAT, but differ in being -VOLITIONAL and -AFFECTED. Profile 4 verbs include *forget*, and

[4] For the individual verb frequency and the frequency of the passive use of all 30 AoA verbs, see Table 8.

[5] Notably, *eat* and *like* are outliers for verb frequency. When we remove these verbs from the analysis, we find even less correlation ($r = 0.25$).

are like Profile 3 verbs in being -STATIVE, -VOLITIONAL, and -AFFECTED, but differ in also being -ACTIONAL and +SUBJ-EXP. Profile 5 verbs include *hate*, and are like Profile 4 verbs in being +SUBJ-EXP, but are additionally +STATIVE.

Table 6: Lexical semantic profiles comprised of the seven lexical semantic features for example verbs with different experimentally observed ages of acquisition (AoA).

	AoA						
	3yrs	**3-4yrs**		**4-5yrs**			**5yrs**
	carry	chase	annoy	fix	find	forget	hate
Profile	**1**	**1**	**2**	**1**	**3**	**4**	**5**
ACTIONAL	1	1	0	1	1	0	0
STATIVE	0	0	1	0	0	0	1
VOLITIONAL	1	1	1	1	0	0	0
AFFECTED	1	1	1	1	0	0	0
OBJ-EXP	0	0	1	0	0	0	0
SUBJ-EXP	0	0	0	0	0	1	1
AGT-PAT	1	1	0	1	1	0	0

Table 7: AoA predictions (Pred AoA) for example verbs based on lexical semantic profiles (Pr).

Pr	**Ex verbs**	**Pred AoA**
1	bump, crash fix, chase, hug	3yrs
2	flatter, hurt	3-4yrs
3	search discover	4-5yrs
4	spot, notice overhear	4-5yrs
5	believe, miss know, remember	5yrs

Taken together along with the results for all 30 verbs shown in Table 8, these profiles suggest a natural developmental trajectory for the lexical semantic cues that influence children's ability to interpret *by*-phrase passives, as per the predictions in Table 7. This lexical semantic profile hypothesis would predict that the discrepancies between the lexical semantic profiles for some verbs and the observed AoA (e.g., Profile 1 verb *fix* with an observed AoA of 4-5yrs) are due to vagaries of the age of the children tested experimentally for those verbs. For example, if *fix* were tested with children age 3, this hypothesis would predict above-chance performance on *fix*'s *by*-phrase passive. This prediction is something that can be experimentally evaluated.

4. Discussion & future directions

Table 8 summarizes how a verb's lexical semantic profile seems to better predict observed AoA than individual verb frequency or passive frequency in children's input. For most verbs, the lexical semantic profile qualitatively aligns with the observed AoA, while the verb and passive input frequencies do not. We interpret this to mean that children may organize verbs into lexical semantic classes when learning which are passivizable.

Our results suggest the need to further investigate how children perceive the lexical semantic features available and the frequency of these features in their input. First, given the predicted AoAs of the lexical semantic profile hypothesis, we should experimentally evaluate these predictions. As mentioned above, Profile 1 verbs like *bump, crash, fix, chase* and *hug* should be learned by age 3. We should also assess when verbs of other profiles are learned, testing a collection of verbs spanning the five profiles observed so far as shown in Table 7. This would provide a clear empirical baseline for the lexical semantic feature hypothesis, with consistent experimental methodology used to assess children's *by*-phrase passive knowledge.

Second, we can also examine the impact of individual lexical features involved in these lexical semantic profiles. For example, a novel verb-learning experiment could be designed that manipulates the presence of specific lexical semantic features (e.g., +/-ACTIONAL). Then, we can assess whether these lexical semantic feature manipulations affect children's acceptance of the novel verb in *by*-phrase passives. Importantly, we can assess whether the impact of lexical features changes over development. If so, this would suggest that certain features are more accessible than others at different developmental stages.

We can also evaluate a version of the frequency hypothesis based on lexical semantic features: Does frequency of lexical semantic features in the passives in children's input relate to the AoA of

Table 8: Observed age of acquisition (AoA) for the 30 verbs with an AoA available, along with their lexical semantic profile (Prof), individual verb frequency (Vb freq), and passive use frequency (Pass freq).

AoA	Vb	Prof	Vb freq	Pass freq	AoA	Vb	Prof	Vb freq	Pass freq
3	carry	1	41	0	3-4	annoy	2	0	0
3	drop	1	120	0	3-4	frighten	2	19	0
3	eat	1	654	2	3-4	scare	2	12	2
3	hold	1	234	0	3-4	shock	2	0	0
3	hug	1	13	1	3-4	surprise	2	11	1
3	kick	1	34	0	3-4	upset	2	0	0
3	kiss	1	31	2	4-5	fix	1	215	6
3	push	1	195	1	4-5	paint	1	43	1
3	shake	1	29	0	4-5	find	3	327	0
3	wash	1	99	3	4-5	forget	4	67	0
3-4	chase	1	26	0	4-5	spot	4	0	0
3-4	hit	1	198	1	5	hate	5	15	0
3-4	pat	1	4	0	5	like	5	1150	0
3-4	pull	1	196	0	5	love	5	114	2
3-4	squash	1	6	3	5	remember	5	290	0

verbs possessing these features? This can be accomplished via a corpus analysis similar to what we have conducted in this study, but focused on the frequency of the lexical semantic features rather than individual verbs.

Based on the corpus analysis of lexical semantic feature frequency and experimentally determined AoAs, we can additionally computationally model how accessible different features would need to be in order to predict the observed AoA. This is similar to the approach of Gagliardi et al. (2017), where children's ability to use the frequency information available to them varies. In our case, this would correspond to children heeding certain lexical semantic features while also being unaware of others at different developmental stages. The accessibility of lexical semantic features determined by this computational modeling approach can be compared against experimental results from a novel-verb learning study like the one described above, which manipulates the impact of specific lexical semantic features on children's performance.

From a knowledge representation standpoint, we note that the 7 lexical semantic features investigated here were proposed as a description of the relevant verb properties. However, it's unclear if they are truly separate or if instead there are overlaps that would be better represented with a smaller number of features (e.g., ACTIONAL vs. AGT-PAT). Future theoretical work can investigate other lexical semantic feature representations that are also compatible with the empirical data collected so far.

5. Final remarks

This study has provided a synthesis of the experimental literature and an analysis of children's input with respect to the acquisition of the *by*-phrase passive in English. Our findings underscore the role of lexical semantic features – and in fact, collections of these features into profiles – that correspond very well to children's observed age of acquisition. This contrasts with the role of individual verb frequency and individual verb passive use frequency, which seem to offer very little explanatory power. This study thus provides a strong empirical foundation for future experimental, corpus, computational, and theoretical investigations about the learnability of the English passive, based on lexical semantic features.

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